

Sustainable Transportation

Accelerating Widespread Adoption of Energy Efficient Vehicles & Fuels

Transportation accounts for 71% of U.S. petroleum use and 33% of the nation's carbon emissions, and predicted surges in population growth will trigger ever greater demand for fuel to power vehicles. While energy efficient transportation strategies have the potential to simultaneously slash oil consumption and reduce greenhouse gas (GHG) emissions, a truly sustainable solution will require more than just putting drivers behind the wheels of new fuel-efficient cars.

As the only national laboratory dedicated 100% to renewable energy and energy efficiency, the U.S. Department of Energy's National Renewable Energy Laboratory (NREL) accelerates widespread adoption of high-performance, low-emission, energy-efficient passenger and freight vehicles, as well as alternative fuels and related infrastructure. Researchers collaborate closely with industry, government, and research partners, using a whole-systems approach to design better batteries, drivetrains, and engines, as well as thermal management, energy storage, power electronic, climate control, alternative fuel, combustion, and emission systems.

NREL's sustainable transportation research, development, and deployment (RD&D) efforts are not limited to vehicles, roads, and fueling stations. The lab also explores ways to save energy and reduce GHGs by integrating transportation technology advancements with renewable energy generation, power grids and building systems, urban planning and policy, and fleet operations.

Researchers' deep understanding of factors that impact industry and consumer acceptance breaks down market barriers and speeds deployment of new technologies. Unbiased expert research and guidance—backed by real-world data and analysis, as well as proven systems, tools, and processes—empower partners to make informed sustainable transportation decisions that fit operational priorities.

Photos from top: A fuel cell electric vehicle powered by hydrogen produced by wind energy at NREL's National Wind Technology Center (NWT). Photo by Dennis Schroeder, NREL19512-C.

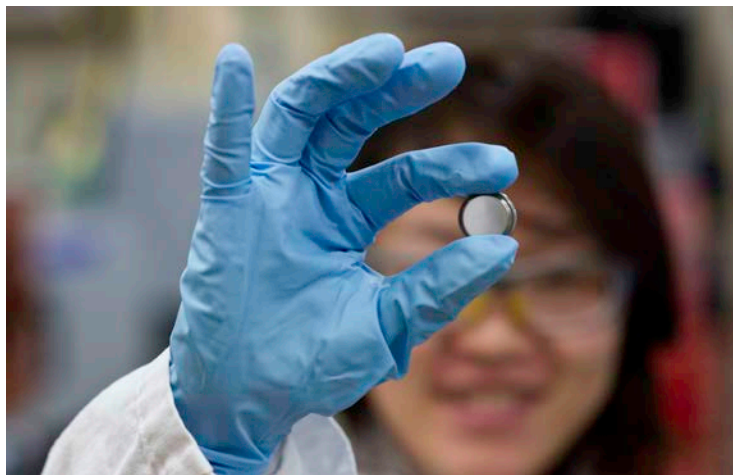
Thermograph of a heavy-duty vehicle undergoing evaluation at NREL's Vehicle Testing & Integration Facility (VTIF). Photo by Dennis Schroeder, NREL 26770-C.

Electric vehicles at a VTIF charging station connected to a solar microgrid. Photo by Dennis Schroeder, NREL 26238.



Innovative Vehicle, Fuel & Infrastructure RD&D

While electric-drive vehicles (EDVs)—hybrid, plug-in hybrid, and fully-electric battery and fuel cell vehicles—promise to curb GHGs and diminish America’s need for imported oil, they currently command a relatively tiny market share. NREL researchers are simultaneously exploring ways to optimize the legacy internal combustion technology that makes up the vast majority of vehicles on today’s roads, while developing the EDV, fuel cell, and biofuel technologies needed to transition to a virtually net-zero emissions, non-polluting fleet. This research and development (R&D), paired with deployment support, touches nearly every type of automotive system and class of on-road vehicle, at scales ranging from component materials to vehicle fleets.



Energy Storage

The design of high-performance, cost-effective, and safe EDV energy storage systems can present considerable challenges, especially in the critical area of thermal control. The most expensive of EDV components, batteries have a profound impact on vehicle performance and range, as well as sticker price. As the country’s recognized leader in battery thermal management research, NREL conducts testing, modeling, simulation, and system evaluation activities to assess energy storage components at the materials, cell, pack, and systems levels.

Power Electronics & Electric Machines

While power electronics help run a wide range of systems in conventional gas-fueled automobiles, EDVs rely even more heavily on these components. NREL R&D is making wide-scale adoption of EDVs more feasible by developing power electronics and electric motor technologies and components with superior reliability, efficiency, and durability, while dramatically decreasing costs. This work has established the lab as a vital resource for reliability and thermal management of motor controllers, inverters, and traction motors.



Hydrogen & Fuel Cells

NREL researchers assess and validate hydrogen fueling infrastructure and fuel cell-powered light-duty vehicles, buses, forklifts, and backup and stationary power systems in real-world operation. The National Fuel Cell Technology Evaluation Center provides secure management, storage, and processing of proprietary data from industry, playing a crucial role in the independent analysis of hydrogen fuel cell technologies. The lab also guides stakeholders in the safe operation, handling, and use of hydrogen.



Photos from top: Researcher with coin cell battery in NREL’s Materials Laboratory. Photo by Dennis Schroeder, NREL 21993.

Engineer calibrating equipment in NREL’s Power Electronic Laboratory. Photo by Dennis Schroeder, NREL 22321.

Drivers fueling a fuel cell electric vehicle with hydrogen at the NWTC. Photo by Dennis Schroeder, NREL 28358.

Fuels & Engines

More energy-efficient and environmentally friendly vehicles call for simultaneous increases in powertrain efficiency and reductions in emissions, requiring substantial advances in internal combustion engines. In turn, advances in engine combustion rely on thorough understanding of fuel properties, especially ignition kinetics behavior. By focusing on the intersection of fuel physical and chemical properties, ignition kinetics, combustion, and emissions, NREL is supporting coordinated development of biofuels, advanced petroleum-based fuels, and advanced combustion engines.

Climate Control

Energy consumed for heating and air conditioning can significantly reduce EDV range—in some cases by as much as 68%. More efficient climate control systems can increase the range of electric-drive passenger vehicles, while diminishing fuel consumption of diesel-powered heavy-duty vehicles. NREL researchers are exploring thermal load reduction strategies and improving energy efficiency while maintaining the comfort that drivers expect.

Fleets

Trucks move more than 13 billion tons of freight across the United States each year. NREL helps truck manufacturers and fleet managers pinpoint fuel efficient and low-emission strategies that support bottom line and operational goals. Researchers' customized evaluations—of existing equipment and practices, energy-saving alternatives, and implementation considerations—along with web-based tools using validated data from field-based measurements factor in the multitude of fleet-specific variables needed to ensure meaningful benefits for large-scale deployment.

Partners in Innovation

Partners from government, industry, and academia tap NREL vehicle and fuel, hydrogen and fuel cell, biomass, deployment, energy analysis, and energy system integration expertise for innovative RD&D in support of:

- Electric, hybrid, fuel cell, and conventional vehicle technologies
- Biofuels, hydrogen, natural gas, propane, and petroleum-based fuels
- Charging and fueling infrastructure.

For information on sustainable transportation partnership opportunities, contact Alex Schroeder: alex.schroeder@nrel.gov, 303-275-3790.



Photos from top: Researchers with test samples in NREL's Fuel Chemistry Laboratory. Photo by Dennis Schroeder, NREL 21940.

Technician connecting a car and thermal manikin to climate control monitors at the VTIF. Photo by Dennis Schroeder, NREL 32142.

Engineer assessing performance of a fleet vehicle at NREL's Renewable Fuels & Lubricants Laboratory. Photo by Dennis Schroeder, NREL 22750.

Cross-Cutting Initiatives

A truly sustainable transportation future will rely on widespread adoption of multiple solutions, including alternative fuels, EDVs, a grid powered by renewable energy sources, new approaches to fueling and charging, and innovative systems of vehicle connectivity—as well as more fuel-efficient gasoline-powered vehicles. In addition to testing and evaluation activities that span a broad spectrum of research areas, NREL expertise has established the laboratory as a national trailblazer in a wide range of cross-cutting areas.

Thermal Management Research

Optimized thermal management can increase electric vehicle battery power by more than 20% and decrease climate control systems' energy demands by as much as 68%. NREL research focused on energy storage, power electronic, and climate control system operating temperature aims to improve vehicle performance, range, reliability, lifespan, and affordability.

Medium-/Heavy-Duty Vehicle Research & Deployment

Freight transportation accounts for about 26% of all transportation-sector petroleum fuel use. Real world-based guidance from NREL helps manufacturers develop and fleet managers deploy energy-efficient, emissions-reducing technologies and operational practices for medium- and heavy-duty vehicles.

Fuel, Engine & Infrastructure Co-Optimization

New fuels, engines, and infrastructure will be required to meet ambitious energy saving and GHG reduction goals. NREL is exploring the interface of fuel chemistry, ignition kinetics, combustion, and emissions to maximize the energy delivered by and minimize emissions associated with alternative and petroleum-based fuels, while ensuring infrastructure compatibility.

Transportation Data, Analysis & Tools

Decisions are only as strong as the information that steers them. NREL serves as the nation's most credible and complete transportation energy-efficiency clearinghouse for validated, up-to-date statistics, data analysis, and tools, pairing information from government and private-sector partners with expertise in analysis and applications.



Researchers explaining visualizations of vehicle energy storage models and simulations. Photo by Dennis Schroeder, NREL 22008

Vehicle-to-Grid Integration

Vehicle-to-grid technology can balance intermittent renewable resources, enhance grid stability, reduce peak-hour electricity demand, and address electric vehicle driving-range limits. NREL researchers are developing and evaluating fully integrated systems that connect cars, power grids, and renewable energy sources.

Technical Assistance & Outreach

Widespread deployment of energy efficient vehicles requires the education and support of end users. NREL experts support regional and municipal organizations with technical advice, market barrier identification and eradication, policy and compliance guidance, partnership cultivation, and stakeholder engagement.

Reliability & Durability Research

Electric vehicle systems and components must perform reliably in a wide range of conditions to meet consumer expectations. NREL R&D focused on improving the reliability and extending the lifespan of power electronic and energy storage components and systems make EDVs more viable in the marketplace.

Learn More

To learn more about NREL's sustainable transportation RD&D, visit www.nrel.gov/transportation

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